Eco Char	Vital Sign Category	Monitoring Objectives	VS Id#	Vital Sign	Monitoring Question(s)	Monitoring Method	Metrics	Vital Sign Rank (0-5)	COMMENTS / NOTES
Human activities & cultural practices	Soundscapes	Monitor sound sources, frequencies, occurrence, and levels	H1	Alien, Natural, Human Soundscapes	Are alien species sounds appropriate to management zone? Are naturally present sounds maintained at appropriate frequencies, occurrence, db levels?	point/plot sampling	frequency (hz), frequency (time), Sound durations, Sound levels, sound source identification	2.6	
	Viewscapes / Lightscapes	Monitor landscape / seascape appearance	H2	Viewsheds	Are landscapes/seascapes changing?	historical photos	qualitative	2.7	
		Monitor light levels and characteristics of light/dark cycles	H3	Lightscape & Night sky	Are natural light/dark cycles maintained as appropriate (eg no inappropriate shading, etc)? Is artificial light restricted to basic human safety needs only?	above ground (aerial or satellite) vs on ground measurements (photographs)	Light intensity, spatial distribution, temporal frequency	2.7	
	Land Use	Monitor points of entry for invasive species	H4	Alien Invasive Species Points of Entry	What are points of entry for invasive species, ALL taxa? What species are being introduced--reaching the islands?	Point / port of entry monitoring	Number, identification of species detected / interdicted	3.4	
		Monitor water use adjacent to or upstream from park boundaries	H5	Water Use(s) Within & Surrounding Parks	Which resources are most at risk due to conflicting water uses (withdrawals, diversions, inputs)?	Stream gages, well monitoring/logs	Volume, rate	3.0	
		Monitor land use adjacent to, or upstream of, park boundaries	H6	Land Use(s) Within & Surrounding Parks	What areas are most at risk due to conflicting adjacent changes in land use (e.g. ranching, urbanization)?	Aerial photography, mapping, plots	change detection maps	3.4	
	Park Use & Activities	Monitor debris-trash occurrence in coastal, riparian, wetland, and lacustrine habitats; in or near high use areas	H7	Litter/debris	What are levels of litter within parks? Where is littering/ dumping of trash taking place? What are areas of marine debris deposition?	surveys of activity & locations	quantity present / removed	3.1	
		Monitor patterns of park visitation, use & damage (terrestrial & marine)	H8	Marine Recreational Activities & Groundings/Anchor Damage	Are use levels changing? What are trends?	plots, transects, and surveys	density of fish line, density of lead sinkers on bottom, level/degree of trampling, percent broken coral, quantity of beach users, quantity of diver hours, water films	2.5	
			H9	Footprint & Visitor Use Patterns	Are locations and/or intensity in use areas (visitor or management) changing? Are use levels associated w/detectable levels of resource change?	VERP program, repeated mapping of use areas, plot sampling	erosion, plant cover	3.3	
			H10	Subsistence Farming/Agriculture	What areas are affected by subsistence farming and how are these practices modifying plant communities?	Mapping/gps perimeter of farmed areas, aerial photos	area covered by disturbance, Distribution	1.2	
		Monitor incidence & occurrence of bioprospecting	H11	Bio-prospecting Harvest	Are harvest levels changing? What are trends? Is human harvest changing distribution, abundance, or other population characteristics? What are current trends (research activities) in bioprospecting.	Surveys in various targeted habitats: pharmaceutical plants, thermal pools, coral reefs, intertidal zones, etc. Quantification of research activity, harvest levels, and of targeted population characteristics.	harvest composition, harvest quantity, Research activity	1.9	
		Monitor levels of take & harvest of harvested species (marine, freshwater, and terrestrial) or resources (coral, sand)	H12	Coral/Sand Mining Harvest	Are harvest levels changing? What are trends?	plots/transects and remote sensing	harvest composition, harvest quantity	1.2	
			H13	Culturally Significant Plant Harvest	What impact does gathering of plant materials by humans have on harvested populations?	Transects, plots	Cover, demographics, density	2.5	
			H14	Culturally Significant Vertebrate Species Harvest	Is human harvest changing distribution, abundance or other population characteristics? Can there be a balance between management goals of sustaining population numbers and culturally important species?	Systematic monitoring and/or population surveys of harvested species	collection statistics, counts by class, Creel counts	1.6	
			H15	Reef Fisheries Harvest	Are harvest levels changing? What are trends? Is human harvest changing distribution, abundance, or other population characteristics? Harvest includes legal and illegal take.	Systematic monitoring of fishing and harvest of shellfish and other inverts in coastal areas; population characteristics of target species	catch per unit effort, collection statistics (quantity, age/size), composition, Creel counts, harvest quantity	2.6	
	Management Zones	Monitor patterns and effects of use and management	H16	Management Zone uses	Are locations, extent and/or intensity in use areas (visitor or management) changing? Are use levels associated w/detectable levels of resource change?	mapping	quantify and qualify uses and extent(s)	3.1	
		Monitor effects of management practices on wilderness character	H17	Wilderness Areas - HAVO, HALE, other Unofficial	Monitor to identify the need for, or effects of, management actions	Limits of acceptable change. Nature, magnitude, and source of impacts	Limits of Acceptable Change (LAC)	1.1	

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Physical / Chemical Conditions	Climate & Air Quality	Monitor visibility	P1	Visibility	Is sight distance, extinction, and quality reduced?	Aerosol filters, cameras	sight distance (extinction coefficient), particulate concentration, turbidity	2.9	
		Track rates of atmospheric deposition	P2	Atmospheric Deposition: Wet (direct & occult) and Dry	Document differences in Human vs. Volcanic vs. other natural sources	Station data	Total Hg & Hg concentration, Total N & N concentration, Total S & S concentration	2.1	
		Track atmospheric concentrations of particulates and gases, levels of radiation--emphasizing those with known human health or environmental impacts	P3	Atmospheric Gases: Climate Change Indicators, Human Pollutants, Natural-Volcanic	How are atmospheric gas concentrations changing and are these changes having ecological or human health impacts? How does volcanic activity influence air quality?	Station data	Air toxics concentration/human, CO2 concentration/climate change, Nox concentration/humans, O3 concentration/humans, S concentration/volcanic	2.2	
			P4	Marine Aerosols	How do marine aerosol levels vary over time and space?	station data	species, concentrations	1.4	
			P5	Atmospheric Particulates: Climate Change Indicators, Human Pollutants, Natural-Volcanic	How are atmospheric particulate species and concentrations changing and are these changes having ecological or human health impacts?	Station data	Dust, Particle analyses/species: 10-2.5-1 micron cuts, species	2.2	
			P6	Solar radiation	How are solar radiation inputs, UV-B, photosynthetically active radiation, or other wavelengths, fluxes changing?	UV-B monitoring (eg Brewer's), PAR sensors, total flux	upwelling / downwelling	2.7	
		Monitor core weather/climate conditions within each park (on each island)	P7	Weather & Climate	What are ranges of climate parameters within each park? Are they changing?	Weather stations (RAWS, COOP, NPS-ARD).	fog, wind, temperature, solar radiation, soil moisture, relative humidity, fuel moist/temp, wetness, precip (direct & occult)	3.4	
		Monitor frequency and intensity (severity) of extreme events (hurricanes, waves, winds, rain, etc.)	P8	Extreme events (weather & ocean)	What are impacts of extreme events? How often do they occur, and at what intensity? What are temporal trends?	NOAA, USGS, NWS	hurricane extent/intensities, ENSO extent/intensities, etc	3.0	
		Identify and monitor spatial patterns of climate, such as trade-wind inversion elevation, lifting condensation level, lapse rates, etc.	P9	Climate Representations - 2- & 3- dimensional	Provide baseline data to help evaluate stability and variability in climate affecting natural populations, processes, and large scale ecological drivers?	modeling or mapping	Lifting condensation Level, Temperature lapse rates, Trade-Wind Inversion, Cloud patterns (incl. radiation)	1.7	
	Soil, Water, & Nutrient Dynamics	Monitor physical ocean dynamics--ocean currents, sea level, tides/swell	P10	Ocean/Physical Dynamics: Currents, Sea Level, Tides/Swell	Is variation within normal range? What are temporal trends?	Tide Gauge, GIS, Buoy data, satellite data	buoy data, instrument data, Mapping velocity and direction, maximum signal wave height, satellite data, sea level, flood timing / magnitude, tide fluctuations	2.7	
		Monitor cycles of nutrients and elements within soils and water--including carbonate (oceanic), nitrogen, and phosphorous	P11	Biogeochemical Cycles - Nutrient Cycling	How are fluctuations changing over time (source, directions, levels of flow)?	monitoring plots	Aquatic senescence, Coral growth-CaCO3 deposition, Forest productivity (litter rain, incremental growth), Key constituents (N, K, CaCO3)	2.5	
		Monitor soil erosion	P12	Soil Erosion	What are causes and locations of soil erosion?	erosion pins, sediment collectors, mapping	Rate of change?	2.9	
		Monitor soil quality trends (physical, toxics/contaminants, other biologic and nutrients)	P13	Soil Quality - Biological	Are soil communities changing?	Soil sampling and analysis	bacteria, fungal/microrhizzal, worms/nematodes/arthropods	1.7	
			P14	Soil Quality- Chemical	Are soil buffering and filtering qualities changing?	Soil sampling and analysis	appropriate WQ measures, cations, pH, soil composition, Total Nitrogen & Total Carbon	1.9	
			P15	Soil Quality- Physical	Are physical soil properties changing?	Soil sampling and analysis	DOC, grain size, moisture content, parent material, percent organic matter, permeability, POC	2.3	
		Monitor condition and extent of soil crusts	P16	Soil Crust Change (Arid-Semiarid habitats)	What are pressures/impacts on soil crusts, and how are they distributed in space and time?	soil and geologic mapping, remote sensing, periodic change analysis	distribution of soil crusts, pH, rainfall, substrate composition, volcanic aerosol composition, wind spd/dir	0.9	
		Monitor trends in surface water flow regimes	P17	Flowing surface water hydrology	What are usual rates & range of flow? What is timing & magnitude of floods or droughts? Is erosion occurring, or are flow channels changing?	gages, sampling at permanent sites	erosion, discharge / recharge, diversion patterns, flood timing / magnitude, withdrawal & consumption rates, stream cross-section, stream discharge, stream gradient	2.7	
		Monitor wetland (incl. anchialine ponds) water flow exchange dynamics, size, and distribution	P18	Wetlands (incl. anchialine pools) hydrology	What are freshwater/saltwater recharge rates? What is habitat extent? What are temporal trends in recharge rates and habitat extent?	measure salinity, residence time, mapping	erosion, flood timing/magnitude, flow, parent material/geomorphology, plant cover/ species present, pool size, depth & salinity, rainfall, sediment loads, stream cross-section, stream discharge, stream gradient	3.2	
		Monitor ground water flow rates and direction of movement (recharge)	P19	Groundwater dynamics	What are rates of subsurface flow? What is level of freshwater/saltwater mixing? What are flow patterns?	well, seep, & spring discharge measurements	discharge/recharge, injections (sewage), permeability, tide fluctuations, withdrawal & consumption rates	2.4	

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Physical / Chemical Conditions	Water Quality		Monitor water quality core parameters	P20	Ground Water Quality Core parameters	Is variation within normal range? What are temporal trends?	water sampling from dedicated monitoring wells in addition to supply wells	temperature, pH, salinity (sp. cond.), Dissolved Oxygen,	2.8	
				P21	Marine Water Quality Core parameters	Is variation within normal range? What are temporal trends?	in-situ measurements and collection of samples at established sites including controls	temperature, pH, salinity (sp. cond.), Dissolved Oxygen, PAR	3.3	
				P22	Surface Water Quality Core parameters	Is variation within normal range? What are temporal trends?	in-situ measurements and collection of samples at established sites including controls	temperature, pH, salinity (sp. cond.), Dissolved Oxygen, PAR	3.6	
			Monitor supplemental water quality parameters	P23	Ground Water Quality Supplemental parameters	Is variation within normal range? What are temporal trends?	water sampling from dedicated monitoring wells in addition to supply wells	nutrients, total suspended solids/turbidity, chlorophyll A , alkalinity, anions, cations, redox, total organic carbon,	2.6	
				P24	Marine Water Quality Supplemental parameters	Is variation within normal range? What are temporal trends?	in-situ measurements and collection of samples at established sites including controls	nutrients, total suspended solids/turbidity, chlorophyll A , alkalinity, anions, cations, redox, total organic carbon,	2.9	
				P25	Surface Water Quality Supplemental parameters	Is variation within normal range? What are temporal trends?	in-situ measurements and collection of samples at established sites including controls	nutrients, total suspended solids/turbidity, chlorophyll A , alkalinity, anions, cations, redox, total organic carbon,	3.5	
			Monitor microbiological water quality parameters	P26	Ground Water Quality - Microbiology	Is variation within normal range? What are temporal trends?	water sampling from dedicated monitoring wells in addition to supply wells	bacteria, biological oxygen demand	2.9	
				P27	Marine Water Quality - Microbiology	Is variation within normal range? What are temporal trends?	collection of samples at established sites including controls	bacteria, biological oxygen demand	2.8	
				P28	Surface Water Quality - Microbiology	Is variation within normal range? What are temporal trends?	collection of samples at established sites including controls	bacteria, biological oxygen demand	2.9	
			Monitor toxic and contaminant levels in water	P29	Ground Water Quality - Toxics & contaminants	Is variation within normal range? What are temporal trends?	water sampling from dedicated monitoring wells in addition to supply wells	chemical oxygen demand, heavy metals, herbicides, organics, pesticides	2.8	
				P30	Marine Water Quality - Toxics & contaminants	Is variation within normal range? What are temporal trends?	water sampling, sediment sampling, animal tissue sampling	chemical oxygen demand, heavy metals, herbicides, organics, pesticides	3.0	
				P31	Surface Water Quality - Toxics & contaminants	Is variation within normal range? What are temporal trends?	water sampling, sediment sampling, animal tissue sampling	chemical oxygen demand, heavy metals, herbicides, organics, pesticides	3.7	
			Monitor biological invertebrate communities	P32	Marine Water Quality - macroinvertebrates	What are community dynamics of marine & estuarine sediment communities?	benthic community composition (transects, quadrats, traps, trawls, tows)	diversity, species richness, indicator species, recruitment	2.8	
				P33	Surface Water Quality - macroinvertebrates	What are community dynamics of benthic freshwater communities?	benthic community composition of standard sampling units	diversity, species richness, indicator species, recruitment	2.6	
	Geology	Hazards	Monitor surface volcanic activity (lava flows, eruption events & ground deformation)	P34	Volcanic Unrest - Ground Deformation	What role does volcanic activity and deformation play in maintaining public safety, park facilities, and how do they affect natural processes?	Dry and wet tilt meters, dilatometers, GPS	GPS, subsurface temp, tilt meters	1.4	
				P35	Volcanic Unrest - Lava Flows	What role do lava flows play in maintaining public safety, park facilities, and how do they affect natural processes?	Remote sensing, visual observation, tilt meters and dilatometers, GPS ground deformation	tube mapping, flow direction/magnitude, GPS	1.2	
			Monitor volcanic & non-volcanic seismicity	P36	Seismicity of Non-Volcanic Origin	Can we identify trends and predict hazards?	Seismometers (local and global)	tilt meters, seismometers, dilatometers (pressure gauges), EDM (Electronic Distance Measuring)	1.9	
				P37	Seismicity of Volcanic Origin	Can we identify trends and predict hazards?	Seismometers (local and global)	tilt meters, seismometers, dilatometers (pressure gauges), EDM (Electronic Distance Measuring)	1.8	
			Monitor extent, location, and causes of mass wasting events (e.g. landslides)	P38	Mass Geologic Wasting	Can we predict slope failure hazards to protect habitats and human safety? Can we monitor or identify causes? What are temporal trends?	Rainfall and other climactic analyses (precursors and catalysts), stream gauges, remote sensing	soil saturation, soil/ground creep, substrate composition/permeability, substrate distribution	1.6	
		Landforms	Monitor shoreline dynamics	P39	Coastal Shoreline Change (erosion & accretion)	Where are shorelines advancing, retreating, or stable?	tide gauge, GPS, remote sensing, field investigation, periodic change analysis	human development/infrastructure, substrate composition, shoreline aspect/position/slope, sea level, nearshore physical oceanography	3.2	
			Track dune locations and topography	P40	Dune Change (erosion & accretion)	Are drought & desertification influencing topsoil transport and seed/nutrient transport patterns?	remote sensing, field investigation, periodic change analysis	grain size & parent material, rainfall, soil crust development, substrate composition, substrate distribution, veg stabilization, wind spd/dir	0.9	
			Identify and monitor the extent of permafrost	P41	Permafrost on Big Island summits	Is extent of permafrost declining? Influence on ground subsidence, slope failure, etc?	Remote Sensing (ground penetrating radar), satellite thermal analysis, drilling	temperature, volcanic activity (heating), permafrost thickness, rainfall	0.0	
			Monitor karst and non-karst cave and lava tube habitat characteristics, topography, and extent	P42	Cave Environmental conditions	Are cave systems impacted and changing as a result of above ground changes or human activity & cultural practices? Are environmental conditions in caves changing (temp, humidity, light, etc.)?	Station/plot data	litterfall, Species distribution & abundance, human use levels, temperature, humidity, ground compaction, etc.	2.0	
				P43	Cave Geology: non-karst	What are patterns of mineral accretion? Where & when are collapse/skylight formation or enlargement occurring?	geologic mapping, periodic measurement of physical parameters and feature types	dimensions, feature size, extent	2.2	
				P44	Cave Geology: karst	Are changes in karst systems leading to potential bedrock collapse, well yield disparities, poor groundwater quality, soil instability?	Geologic mapping, remote sensing, surface water chemistry, groundwater discharge patterns	baseline mapping, groundwater flow/quality	0.9	

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Biotic Integrity	Terrestrial Ecosystems	Vegetation	Landscape	Monitor patterns of distribution & extent of community types	T1	Soil and Pollen Landscape History	Are intact paleo landscapes being altered?	Mapping; Pollen and charcoal assemblages, soil horizons, etc.	Rate of change?	2.3	
					T2	Ecozone Boundaries	Are locations of ecotones changing? Are the communities that comprise ecological boundary zones changing?	vegetation mapping, landscape photography, high spatial resolution plots	change detection maps	2.1	
					T3	Landscape Fragments, Patch Size, Land Cover	How are the distributions of plant communities and land cover inside and immediately outside the Parks changing over time?	Mapping, repeat photography	FRAGSTAT statistics, Vegetation type	2.6	
				Monitor fire regimes and effect on vegetation	T4	Fire Effects & Dynamics: Vegetation and Landscape Level	What is a natural fire frequency? What changes in plant community composition and structure result from fire? What are the biogeochemical effects of fire?	Transects, plots, histories	change in vegetation structure, Cover, density, erosion, nutrient loss, species composition	2.5	
				Track insect and disease presence during forest dieback	T5	Forest Dieback	What percentage of trees in a populations is declining or dying? What proportion are dying by natural vs. non-native influences? What are temporal trends?	Transects, plots, population surveys	Plant cover, density, vigor, size classes, species composition, Density of herbivores relative to degree of dieback	1.5	
			Community	Monitor community dynamics, structure, function, and composition	T6	Terrestrial Plant Biodiversity	Are there detectable short-term changes in selected native plant communities?	plots, transects	abundance, density, cover, Abundance and trends in selected focal groups of plant species	3.6	
					T7	Long-term Plant Succession	What are long-term trends in plant community composition and structure, regardless of management treatment or land use?	Transects, plots, mapping, remote sensing	Cover, density, vigor, size classes, growth rates, species composition	3.5	
				Monitor effects of management on native communities	T8	Recovery/Change of Native Vegetation with Alien Plant Control	What are trends in plant community composition and structure in response to alien plant control treatments?	Transects, plots	Cover, density, vigor, size classes, species composition, recruitment rates	3.5	
					T9	Recovery/Change of Native Vegetation with Feral Ungulate Control	What are trends in plant community composition and structure after removal or sustained control of feral ungulates? Are habitats damaged by alien ungulate species restorable?	Transects, plots. Monitor fenced areas where ungulates have been removed.	Cover, density, vigor, size classes, species composition	2.4	
					T10	Recovery/Change of Native Vegetation with Invasive Alien Invertebrate Control	Are native plant species recovering where invasive invertebrates are controlled? What are trends in plant community composition and structure following invasive invertebrate control?	Transects, plots	species composition, vigor, size classes, density, Cover, abundance & distribution of alien inverts & native pollinators, flower & seed production	1.8	
			Population	Monitor effects of biocontrol on native and invasive species	T11	Invertebrate Biocontrol of Plants	What is the long-term impact/efficacy on populations of blackberry, passionflower, & other pests? Are non-target plants, especially natives, being affected?	Plots & transects for plants	Infestation rates	1.7	
					T12	Plant Pathogen Biocontrol of Plants	What is the impact/efficacy on populations of control target? Are non-target species being attacked?	Plots & transects	Infestation rates	1.6	
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species	T13	Native Plant Species Protection (T, E, S-o-C species)	What are the distribution, abundance, and demographics of threatened, endangered, and rare native plant species? Are plant populations reproducing at self-sustaining levels?	Mapping, plots, counts in size classes	phenology, survival, soil seed bank, population structure, Distribution, density, reproduction	4.0	
				Monitor disease incidence and impacts, especially on native species	T14	Established Plant Disease & Pathogens	What is the incidence and level of disease in populations? Are diseases/pathogens affecting populations? What are trends in disease/pathogen?			2.9	
					T15	Alien Incipient Plant Disease & Pathogens	Where are disease locations outside parks? What species are they affecting? What are rates and directions of spread? Identify existing disease/pathogen incidence, impact, and trends?			2.6	
				Monitor extent and response to treatment of established invasive species	T16	Established Alien Species - Plants	What is the distribution and abundance of established alien plants? What is the rate of spread of alien plants?	Mapping, transects, plots, counts in size classes	Distribution mapping, frequency	4.0	
				Monitor occurrence of non-established (incipient) invasive species	T17	Alien Incipient Invasive Plants	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Passive surveillance and follow-up; surveys in high- risk sites (eg.roadsides, trails, ports, disturbed sites)	Presence/ absence, rapid assessment of extent of infestation	3.7	
Biotic Integrity	Terrestrial Ecosystems	Consumers	Community	Monitor community dynamics, structure, function, and composition	T18	Terrestrial Invertebrate Biodiversity	What are trends in distribution and abundance of hyper-diverse groups w/in parks?	Population surveys, transects, plots	Diversity, evenness, endemism	2.9	
					T19	Terrestrial Vertebrate (including off-shore islets refugia) Biodiversity	Are there long-term changes in selected native vertebrate communities?	Population surveys	Abundance and trends of selected vertebrate species or groups	3.3	
				Monitor effects of management on native communities	T20	Recovery/Change of Native Invertebrates Communities with Native Plant Restoration	What native species are recolonizing restored areas? Which ones are not?	Transects, plots	abundance, Presence, trends of selected species or groups	2.5	
					T21	Recovery/change of Native Wildlife and habitats (including wetlands) with restoration of native vegetation	What are trends in plant community composition and structure resulting from outplanting and seed-sowing activities? What is the response of native vertebrate and invertebrate populations to plant community restoration? What are priority plant species that should be restored?	Transects, plots (monitoring of areas where seeds have been broadcast and native species outplanted)	size classes, vigor, species composition, seedling recruitment, growth rates, Cover, animal reproductive success, animal popn size, animal popn growth rates, survivorship, density	3.2	

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Biotic Integrity	Terrestrial Ecosystems	Consumers	Population	Monitor effects of biocontrol on native and invasive species	T22	Invertebrate Biocontrol of Invertebrates	What is the impact of biocontrol agents on native moths, beetles, & parasitoids? What is the impact/efficacy on target populations?	Population surveys, rearing	Infestation rates	1.7	
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species	T23	Forest Birds and Bats (includes T & E spp.)	Are distribution, abundance, other population characteristics, or habitat changing? Determine population levels over time.	Population surveys (forest bird methods differ from those for raptors or bats)	Abundance / density, distribution	3.1	
					T24	Herps (native)	Are distribution, abundance, other population characteristics, or habitat changing? Determine population levels over time.	Population surveys	Abundance / density, distribution	1.7	
					T25	Invertebrate Charismatic or Species of Concern	Are distribution, abundance, other population characteristics, or habitat changing? Determine population levels over time.	Population surveys	Abundance / density, demographics, distribution	3.2	
					T26	Seabirds (including T & E spp.)	Are distribution, abundance, other population characteristics, or habitat changing? Determine population levels over time.	Population surveys	Abundance / density, distribution	3.5	
					T27	Shorebirds and Waterbirds (including T & E spp.)	Are distribution, abundance, other population characteristics, or habitat changing? Determine population levels over time.	Population surveys	Abundance / density, distribution	3.3	
					T28	Terrestrial Invertebrates Associated with Habitat Quality	What are trends in invertebrate indicator species?	Population surveys	abundance, distribution, demographics	2.7	
					T29	Terrestrial Invertebrate Species Protection (T, E, S-o-C Species)	Are distribution, abundance, other population characteristics, or habitat changing?	Mapping, plots, population surveys	abundance, distribution, demographics	2.9	
				Monitor disease incidence and impacts, especially on native species	T30	Established Disease & Pathogens of Terrestrial Vertebrates	What is the incidence and level of disease in populations? Are diseases/pathogens affecting populations? What are trends in disease/pathogen?	Continue to monitor bird, bat, and herp populations (VCP, mist-netting)	incidence, Presence/ absence	2.5	
					T31	Alien Incipient Disease & Pathogens of Terrestrial Vertebrates	Where are disease locations outside parks? What species are they affecting? What are rates and directions of spread? Identify existing disease/pathogen incidence, impact, and trends	Surveys in high risk sites; passive surveillance,; education, outreach, public reporting, and follow-up	Presence/absence, rapid assessment of extent of infestations (distribution, identification and numbers of host and/or vector species involved)	2.5	
				Monitor extent and response to treatment of established invasive species	T32	Established Alien Species - Feral Ungulates	What are the relative abundance and population trends of feral ungulates? What are the impacts of feral ungulates? Is competition from invasive spp changing distribution, abundance, etc. of native spp.?	Animal activity transects	Index of ungulate damage (to both plants and animals as appropriate) index of erosion damage by ungulates, plant species recovery after removal of ungulates	2.4	
					T33	Established Alien Species - Invasive Terrestrial Invertebrate Pests of natural systems	How effective is control? What are the abundance, distribution, and seasonal and year-to-year variations in populations? What are trends in impact?	Transects, plots, population surveys	abundance, distribution, demographics	2.4	
					T34	Established Alien Species - Predatory Terrestrial Vertebrates	Are native plant and animal species abundance or distribution changing in response to predators or predator control? What are trends in invasive species populations?	Treatment and control Transects/plots (for plants); other methods appropriate for native vertebrates of interest (VCP, transects, etc.); population surveys for predators	Plants: species composition, population and/or community structure. Animals: VCP, transects, other methods to monitor critical life stages identified as impacted by predators. Predator population indices, presence/ absence	3.4	
					T35	Established Alien Species - Terrestrial Invertebrate Pests (agricultural)	Monitor population fluctuations to determine when additional control actions are needed	Population surveys	Infestation rates of native and alien fruits	1.8	
					T36	Established Alien Species - Terrestrial Invertebrate Pests (human structures)	Characterize extent of impact invertebrate pests are having on historical and other culturally significant structures?	Periodic sampling of structures	Infestation rates	1.9	
	Terrestrial Ecosystems	Consumers	Population	Monitor occurrence of non-established (incipient) invasive species	T37	Alien Incipient Invasives - Predatory Terrestrial Vertebrate	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Passive surveillance and follow-up on reports; education, outreach, and public reporting; surveys in high- risk sites	Predator population indices, presence/ absence, rapid assessment of extent of infestation	3.3	
					T38	Alien Incipient Invasives - Fungi	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Passive surveillance and follow-up on reports; education, outreach, and public reporting; surveys in high- risk sites	distribution, Presence/ absence, rapid assessment of extent of infestation	2.0	
					T39	Alien Incipient Invasives - Terrestrial Invertebrates	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Passive surveillance and follow-up on reports; education, outreach, and public reporting; surveys in high- risk sites	distribution, Presence/ absence, rapid assessment of extent of infestation	2.2	
					T40	Alien Incipient Invasives - Vertebrates	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Passive surveillance and follow-up; surveys in high- risk sites	distribution, Presence/ absence, rapid assessment of extent of infestation	2.6	
		Cave Systems	Community	Monitor changes in cave communities	T41	Cave & lava tube communities	Are cave (biotic) communities changing? What are temporal trends?	Population surveys, root type and abundance	abundance, distribution, demographics	2.0	

Eco Char	Vital Sign Category			Monitoring Objectives	VS Id#	Vital Sign	Monitoring Question(s)	Monitoring Method	Metrics	Vital Sign Rank (0-5)	COMMENTS / NOTES
Biotic Integrity	Freshwater Ecosystems	Producers		Monitor community composition, structure, and productivity	F1	Community dynamics of primary producers	What species & groups are present? What are normal rates of productivity? Where are algal blooms present?	periodic benthic sampling	abundance, distribution, demographics	2.5	
		Consumers	Community	Monitor community dynamics, structure, function, and composition	F2	Aquatic and Riparian Species (vertebrate and invertebrate) Biodiversity	Are there long-term changes in selected aquatic native communities?	population surveys, transects	Abundance and trends of selected species or groups	3.5	
			Population	Monitor disease incidence and impacts, especially on native species	F3	Freshwater Animals Disease & Pathogen	What is the incidence and level of disease in populations? Are diseases/pathogens affecting populations? What are trends in disease/pathogen?	visual surveys of possibly affected populations	disease types, occurrence, tissue samples, vectors	2.2	
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species	F4	Amphidromous Fauna Size-Age Structure, Reproduction and Recruitment	Is variation within normal range, why not? What are selected short- and long-term trends? Is recruitment at normal levels?	Size & age structure: transects, plots. Repro & recruit: downstream larval drift & upstream immigration.	abundance of size classes, recruitment and reproduction rates, species diversity	2.1	
				Monitor extent and response to treatment of established invasive species	F5	Established Alien Species - Predatory Freshwater (vertebrate and invertebrate)	What is the extent of present infestations? What is the impact of predatory invasive species on native species abundance and distribution? What are effective management strategies for invasive species removal?	Periodic sampling of freshwater habitats.	abundance, Distribution	2.9	
				Monitor occurrence of non-established (incipient) invasive species	F6	Alien Incipient Invasives - Predatory Freshwater (vertebrate and invertebrate)	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Periodic sampling of freshwater habitats outside of parks	abundance, Distribution	2.8	
	Marine Ecosystems	Benthic	Landscape	Monitor patterns of distribution & extent of community types	M1	Coral Growth (erosion & accretion)	Is net accretion or erosion occurring? What are spatial patterns?	monitoring quadrats	coral growth and decline rates, water chemistry	2.7	
					M2	Benthic Habitats	How are the distributions of benthic habitats/communities and coral/algal cover inside and immediately outside the Parks changing over time?	mapping, transects, quadrats	Rugosity, relative abundance, species diversity, indicator species	2.6	
			Community	Monitor community dynamics, structure, function, and composition	M3	Benthic Marine Invertebrates and Algae Biodiversity	Are there long-term changes in composition of selected native communities?	Transects, quadrats (photo, video)	Cover by type, biomass, species diversity, relative abundance, counts	2.8	
					M4	Subtidal - Hard Bottom (coral reef, colonized basalt, etc.)	Is variation within normal range? What are selected (community composition, distribution, physical structure) short- and long-term trends?	transects, quadrats (photo, video), mapping	cover by type, biomass, habitat type diversity, percent cover of species density	2.7	
					M5	Subtidal - Soft Bottom (sand flat, seagrass bed)	Is variation within normal range? What are selected (community composition, distribution, physical structure) short- and long-term trends?	transects, quadrats, mapping	cover by type, biomass, habitat type diversity, percent cover of species density	2.4	
			Population	Track community and population trends in harvested fisheries / collected species	M6	Benthic Reef Fisheries / Collected species (inverts: sea cucumbers, pololo worm, corals; etc)	What are effects (size/age cohort, demographics) of human harvest on fished or gathered species? What are the trends of trackable population parameters? If variance is observed, is it due to harvest? Is variance due to harvest levels?	Transects, quadrats	Counts, biomass, relative abundance	2.7	
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species	M7	Benthic Marine Invertebrates and Algae	Is population variation within normal range (size/age cohort, demographics)? What are population trends?	transects, quadrats (photo, video), mapping	Counts, demographics, biomass, relative abundance, recruitment rate	2.7	
					M8	Coral Growth/Size and Age Structure, and Recruitment	Is variation within normal range (growth, size, and age structure)? What are selected short- and long-term trends?	transects, quadrats (photo, video), mapping	Cover by type, growth rates, recruitment rates, mortality, survivorship	2.6	
				Monitor disease incidence and impacts, especially on native species	M9	Established Coral Disease & Pathogens (including bleaching)	What is the incidence and level of disease in populations? Are diseases/pathogens affecting populations? What are trends in disease/pathogen?	transects, quadrats (photo, video), mapping, incidence	disease types, disease rates, occurrence, vectors, water quality	2.4	
					M10	Alien Incipient Coral Disease & Pathogens	Where are disease locations outside parks? What species are they affecting? What are rates and directions of spread? Identify existing disease/pathogen incidence, impact, and trends	Transects, quadrats (photo, video), mapping, incidence, modeling	Disease rates, occurrence, vectors, recruitment rates	2.5	
				Monitor extent and response to treatment of established invasive species	M11	Established Alien Species - Benthic Marine	Can we detect changing trends in alien and invasive species? What are effects of alien and invasive species on communities? What is response to treatment?	Transects, quadrats (photo, video), mapping	abundance, demography, distribution	2.7	
				Monitor occurrence of non-established (incipient) invasive species	M12	Alien Incipient Invasives - Benthic Marine	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	transects, quadrats, mapping	abundance, demography, distribution	2.8	

Eco Char	Vital Sign Category			Monitoring Objectives	VS Id#	Vital Sign	Monitoring Question(s)	Monitoring Method	Metrics	Vital Sign Rank (0-5)	COMMENTS / NOTES
Biotic Integrity	Marine Ecosystems	Water column (motile)	Community	Monitor community dynamics, structure, function, and composition	M13	Water Column Marine Vertebrates and Invertebrates Biodiversity	Are there long-term changes (community composition, distribution) in selected native communities?	telemetry, quadrats, transects, aerial surveys, tows, traps	Relative abundance, demographics, distribution, movement, diversity	2.8	
			Population	Track community and population trends in harvested fisheries species	M14	Water Column Reef Fisheries	Is variation in community / population parameters due to harvest? What are effects of human harvest on fished or gathered species?	Transects, quadrat	Abundance, demography, size class, recruitment	2.2	
				Monitor disease incidence and impacts, especially on native species	M15	Established Marine Animal (other than turtles) Disease & Pathogens	What is the incidence and level of disease in populations? Are diseases/pathogens affecting populations? What are trends in disease/pathogen?	Incidence, telemetry	disease types, occurrence, tissue samples, vectors	1.9	
					M16	Established Turtle Disease & Pathogens	What is the incidence and level of disease in populations? Are diseases/pathogens affecting populations? What are trends in disease/pathogen?	incidence, telemetry (mark-recapture)	disease types, occurrence, vectors	2.9	
				Monitor extent and response to treatment of established invasive species	M17	Established Alien Species - Water Column Marine	Can we detect changing trends in alien and invasive species? What are effects of alien and invasive species on communities? What is response to treatment?	Transects, quadrats	abundance, demography, distribution	2.5	
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species	M18	Water Column Marine Invertebrates	Is variation within normal range? What are temporal trends?	Transects, quadrats, tows, traps	Abundance, size, demography, recruitment rates	2.8	
					M19	Fish Growth/Size and Age Structure, and Recruitment	Is variation within normal range? What are selected short- and long-term trends?	transects, quadrats, photoquadrats, mapping	abundance of size classes, recruitment rates, species diversity	3.2	
					M20	Marine Species Protection (T, E, S-o-C species)	Is variation within normal range? What are temporal trends?	telemetry, quadrats, transects, aerial surveys	abundance, demographics, distribution, movement	3.3	
				Monitor occurrence of non-established (incipient) invasive species	M21	Alien Incipient Invasives - Water Column Marine	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Transects, quadrats, tows, traps	abundance, demography, distribution	2.1	
		Intertidal	Community	Monitor community dynamics, structure, function, and composition	M22	Intertidal Biodiversity - Vertebrates, Invertebrates, and Algae	Are there long-term changes in selected native communities, distribution, cover?	Population surveys, transects, quadrats	Abundance and trends of selected species or groups, evenness, richness	3.1	
					M23	Intertidal - Hard Bottom	Is variation within normal range? What are selected (community composition, distribution, physical structure, habitat extent) short- and long-term trends?	transects, quadrats	cover by type, habitat type diversity, percent cover of species density	2.2	
					M24	Intertidal - Soft Bottom (sand beach, mudflat, mangrove)	Is variation within normal range? What are selected (community composition, distribution, physical structure, habitat extent) short- and long-term trends?	transects, quadrats, mapping	cover by type, habitat type diversity, percent cover of species density	2.6	
			Population	Track community and population trends in harvested fisheries collected species	M25	Intertidal Reef Fisheries / Collected species (limu, opihi, crabs, fish, etc.)	What are effects of human harvest on fished or gathered species? What are trends in harvested species?	Transects, quadrats, mapping, traps, biomass, percent cover	Demographics, size, recruitment, distribution	2.3	
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species	M26	Intertidal Marine Invertebrates, Fish, and Algae	Is variation within normal range? What are the long / short term trends?	population surveys, quadrats, transects, traps, tows	abundance, distribution, evenness, demography, recruitment	3.0	
				Monitor extent and response to treatment of established invasive species	M27	Established Alien Species - Intertidal Marine	Can we detect changing trends in alien and invasive species? What are effects of alien and invasive species on communities? What is response to treatment?	population surveys, quadrats, transects, traps, tows	abundance, demography, distribution	2.5	
				Monitor occurrence of non-established (incipient) invasive species	M28	Alien Incipient Invasives - Intertidal Marine	Is species present, if so what is the nature and extent of infestation? What are the most effective strategies for detecting and preventing new invasives species? Where should efforts be focused? What are potential impacts?	Transects, quadrats, mapping, vectors, traps	abundance, demography, distribution	2.6	

Intro, Monitoring goals & objectives, Conceptual Models, and Vital Signs

Also use main handout of review materials (http://www.nature.nps.gov/im/units/pacn/monitoring/plan/vs04/review_materials.htm)

Ecological Characteristic	Vital Sign Category			Monitoring Objectives
Human activities & cultural practices	Soundscapes			Monitor sound sources, frequencies, occurrence, and levels
	Viewscapes / Lightscapes			Monitor landscape / seascape appearance
				Monitor light levels and characteristics of light/dark cycles
	Land Use			Monitor points of entry for invasive species
				Monitor water use adjacent to or upstream from park boundaries
				Monitor land use adjacent to, or upstream of, park boundaries
	Park Use & Activities			Monitor debris-trash occurrence in coastal, riparian, wetland, and lacustrine habitats; in or near high use areas
				Monitor patterns of park visitation, use & damage (terrestrial & marine)
				Monitor incidence & occurrence of bioprospecting
				Monitor levels of take & harvest of harvested species (marine, freshwater, and terrestrial) or resources (coral, sand)
	Management Zones			Monitor patterns and effects of use and management
				Monitor effects of management practices on wilderness character
Physical / Chemical Environment	Climate & Air Quality			Monitor visibility
				Track rates of atmospheric deposition
				Track atmospheric concentrations of particulates and gases, levels of radiation--emphasizing those with known human health or environmental impacts
				Monitor core weather/climate conditions within each park (on each island)
				Monitor frequency and intensity (severity) of extreme events (hurricanes, waves, winds, rain, etc.)
				Identify and monitor spatial patterns of climate, such as trade-wind inversion elevation, lifting condensation level, lapse rates, etc.
	Soil, Water, & Nutrient Dynamics			Monitor physical ocean dynamics--ocean currents, sea level, tides/swell
				Monitor cycles of nutrients and elements within soils and water--including carbonate (oceanic), nitrogen, and phosphorous
				Monitor soil erosion
				Monitor soil quality trends (physical, toxics/contaminants, other biologic and nutrients)
				Monitor condition and extent of soil crusts
				Monitor trends in surface water flow regimes
				Monitor wetland (incl. anchialine ponds) water flow exchange dynamics, size, and distribution
				Monitor ground water flow rates and direction of movement (recharge)
	Water Quality			Monitor water quality core parameters
				Monitor supplemental water quality parameters
				Monitor microbiological water quality parameters
				Monitor toxic and contaminant levels in water
				Monitor biological invertebrate communities
	Geology	Hazards		Monitor surface volcanic activity (lava flows, eruption events & ground deformation)
				Monitor volcanic & non-volcanic seismicity
				Monitor extent, location, and causes of mass wasting events (e.g. landslides)
		Landforms		Monitor shoreline dynamics
				Track dune locations and topography
				Identify and monitor the extent of permafrost
				Monitor karst and non-karst cave and lava tube habitat characteristics, topography, and extent
Biotic Integrity	Terrestrial Ecosystems	Vegetation	Landscape	Monitor patterns of distribution & extent of community types
				Monitor fire regimes and effect on vegetation
				Track insect and disease presence during forest dieback
			Community	Monitor community dynamics, structure, function, and composition
				Monitor effects of management on native communities
			Population	Monitor effects of biocontrol on native and invasive species
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
				Monitor disease incidence and impacts, especially on native species
				Monitor extent and response to treatment of established invasive species
				Monitor occurrence of non-established (incipient) invasive species
		Consumers	Community	Monitor community dynamics, structure, function, and composition
				Monitor effects of management on native communities
			Population	Monitor effects of biocontrol on native and invasive species
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
				Monitor disease incidence and impacts, especially on native species
				Monitor extent and response to treatment of established invasive species
				Monitor occurrence of non-established (incipient) invasive species
		Cave Systems	Community	Monitor changes in cave communities
	Freshwater Ecosystems	Producers		Monitor community composition, structure, and productivity
		Consumers	Community	Monitor community dynamics, structure, function, and composition
			Population	Monitor disease incidence and impacts, especially on native species
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
				Monitor extent and response to treatment of established invasive species
				Monitor occurrence of non-established (incipient) invasive species
	Marine Ecosystems	Benthic	Landscape	Monitor patterns of distribution & extent of community types
			Community	Monitor community dynamics, structure, function, and composition
			Population	Track community and population trends in harvested fisheries / collected species
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
				Monitor disease incidence and impacts, especially on native species
				Monitor extent and response to treatment of established invasive species
				Monitor occurrence of non-established (incipient) invasive species
		Water column (motile)	Community	Monitor community dynamics, structure, function, and composition
			Population	Track community and population trends in harvested fisheries species
				Monitor disease incidence and impacts, especially on native species
				Monitor extent and response to treatment of established invasive species
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
				Monitor occurrence of non-established (incipient) invasive species
		Intertidal	Community	Monitor community dynamics, structure, function, and composition
			Population	Track community and population trends in harvested fisheries collected species
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
				Monitor extent and response to treatment of established invasive species
				Monitor occurrence of non-established (incipient) invasive species